



Renewable Resources

**Inventory of and Recycling Alternatives
for Waste Liquid Petroleum
in the Northwest Territories**

FEBRUARY 1987



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Mr. E. Paquin, Manager
Environment Services
Pollution Control Division
Department of Renewable Resources
Government of Northwest Territories
Yellowknife, NWT
X1A 2L9

Dear Sir:

**Reference: Inventory and Recycling Alternatives to
Waste Liquid Petroleum in the Northwest Territories
Final Report**

We are pleased to present our final report on the inventory and recycling alternatives for waste liquid petroleum in the Northwest Territories.

In the study, we have developed an inventory of waste oil in the western Northwest Territories through personal contact with individuals within business, government departments and agencies. Development of recycling and reuse alternatives for the waste oil is based on our experience and contact with operators of re-refineries in Alberta and in other parts of Canada. Details on the approach of the Province of Alberta have been obtained directly through Mr. T. Rogers, a representative of the Waste Management Branch, Alberta Environment.

The following conclusions are drawn from our assessment of the quantity of waste oil available in the Northwest Territories and the recycling and reuse alternatives that may be appropriate for the Northwest Territories:

1. 1.8 million litres of waste oil are produced annually.
2. Re-refining waste oil is economically not attractive under present market conditions.
3. The burning of waste oil as a fuel for heating provides an alternative that appears economically sound, and can substantially reduce the quantities of waste oil that must be disposed.



Mr. E. Paquin, Manager
Environment Services
Department of Renewable Resources
25 March 1987
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We appreciate the opportunity of working for you on this interesting and timely study and we look forward to working with you again in the future.

We trust that this is satisfactory.

Yours very truly,

STANLEY ASSOCIATES ENGINEERING LTD.

A handwritten signature in cursive script, appearing to read "D.R. Burgess".

D.R. Burgess, P.Eng.
Manager, Yellowknife office

A handwritten signature in cursive script, appearing to read "H. J. Bourque".

H. J. Bourque, P. Eng.
Waste Management Engineer

KJF/cr

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ACKNOWLEDGEMENTS

The input and comments from the individuals in private business, government departments and government agencies in preparing the inventory of waste oil in the Northwest Territories is greatly acknowledged. Their input and comments that accompanied the estimates of waste oil generation were very useful in our assessment of the total waste oil in the Northwest Territories. Input and comments from operators of re-refineries in Alberta and in other provinces in Canada are also acknowledged. The input of Mr. T. Rogers, representative from the Waste Management Branch, Alberta Environment, is acknowledged in providing details on the collection programs developed by the Province of Alberta; and in providing comments on the approach of other jurisdictions to waste oil collection, reuse and disposal; and in providing input to potential programs applicable to the Northwest Territories.

Finally, the suggestions and input from Mr. E. Paquin, Manager, Environmental Services, Department of Renewable Resources, Government of the Northwest Territories, are gratefully acknowledged.

1.0 INTRODUCTION

The present study relates to waste oil generation, present disposal practices and the potential for recycling and reuse of the waste oil in the Northwest Territories. This study, in conjunction with other recent studies relating to disposal of beverage containers, and the review of potential landfill sites represent part of the development of a waste management program in the Canadian North.

Recent initiatives in the town of Hay River with respect to the use of waste oil for heat generation are relevant to the present studies; this is a demonstration project for the operation of a waste oil fired heating system for the municipal water supply of the Town of Hay River. The project is part of the DRECT Program (Development and Demonstration Resource and Energy Conservation Technology Program). The project is funded through the DRECT Program and it is being monitored by the Conservation and Protection Department of Environment Canada.

The scope and objectives of the subject study are based on the terms of reference set out in the Stanley Associates Engineering Ltd. proposal addressed to Mr. E. Paquin, Pollution Control Division, Department of Renewable Resources, Government of the Northwest Territories, dated 13 November 1986. The proposal was in response to the specific terms of reference outlined in a letter from Mr. E. Paquin, dated 31 October 1986; the overall objectives of the subject study were as follows:

- inventory of waste liquid petroleum presently generated in the western Northwest Territories.
- inventory of recycling alternatives presently available and associated costs.
- feasibility for a cost-effective recycling of the waste liquid petroleum.

In this report, the inventory of waste liquid petroleum ("waste oil") is presented in Section 2. A review of used oil reprocessing and reuse alternatives, including

re-refining and burning, as well as process constraints, is listed in Section 3. The approach of a number of provinces to waste oil in terms of collection programs and orientation to reprocessing and reuse is presented in Section 4.

Potential alternatives for reprocessing/reusing the waste oil in the Northwest Territories is presented in Section 5 in conjunction with an estimation of costs. Cost comparisons of various strategies are given in Section 6. A set of conclusions and recommendations potentially applicable to the Northwest Territories is presented in Section 7.

2.0 INVENTORY

2.1 APPROACH

The objective in this phase of the project was to assess the quantities of waste oil and contaminated fuels generated in the western service area.

The western service area is defined as that part of the NWT serviced by the Alberta/NWT highway system and/or the MacKenzie River barge system. For the purpose of this study, the area has been divided into four service regions; these are outlined in Figure 2.1.

A questionnaire was prepared and it was used as the basis for an extensive telephone survey of waste oil generators. (A sample questionnaire is given in Appendix 1). Emphasis was placed on the larger producers of waste oil and contaminated fuels, such as Northern Canada Power Commission, the major barge companies, the various levels of Government, mines, airlines and oil companies. However, a considerable number of smaller companies engaged in trucking, construction, fuel distribution and vehicle services were also approached in order to reach all areas and obtain as accurate an estimate as possible.

The calculation of quantities of waste oil from vehicles was based on official registration figures and on information obtained from various trucking companies and service centers with regard to oil change intervals and quantities.

Companies and government agencies surveyed responded with data, in addition to information about current disposal practices and comments on disposal problems. Personnel contacted were very cooperative and provided useful suggestions and comments on the study. Many smaller establishments do not keep records of oil throughput, and most quantities are estimated. For the purpose of this report, these estimates are deemed sufficiently accurate.

For those waste oil producers identified for which data were not available, quantities were estimated, based on experience with similar waste oil producers.

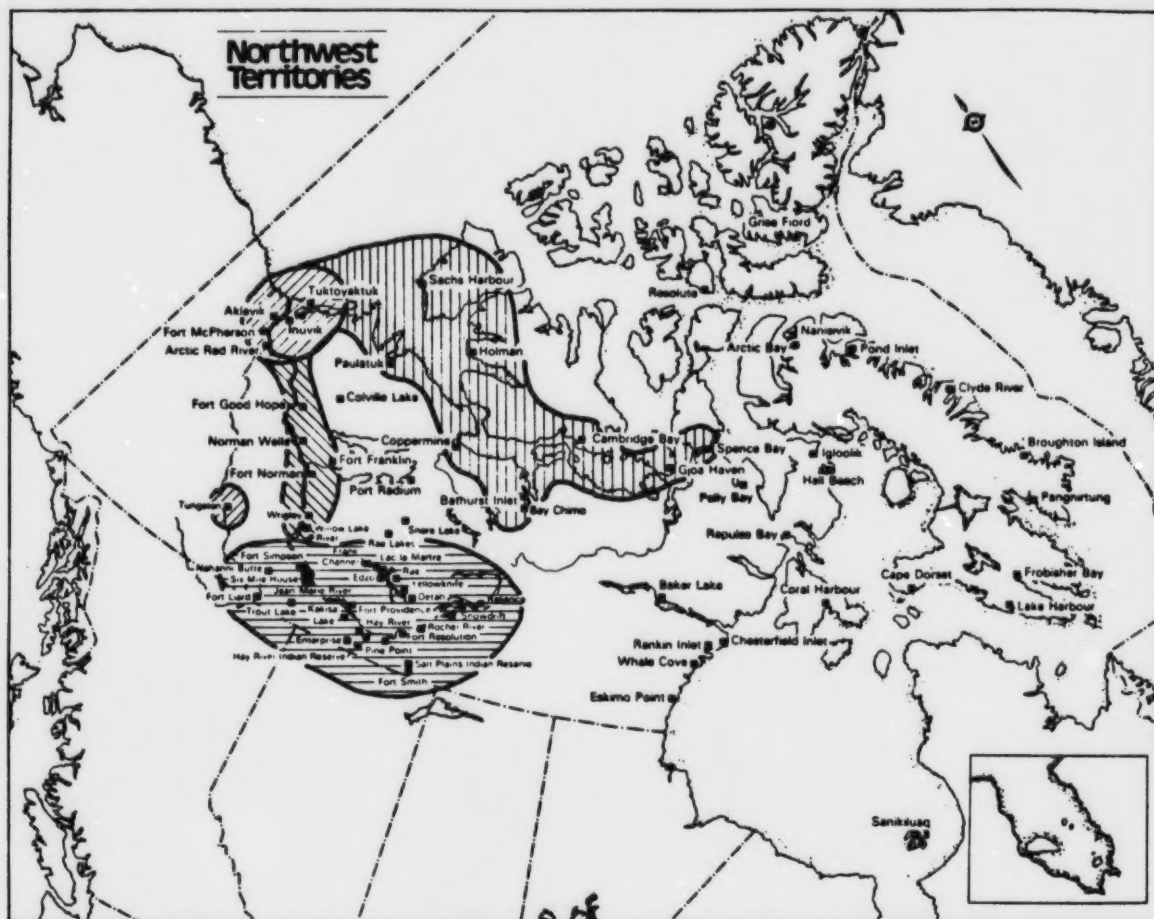
2.2 WASTE OIL GENERATION BY GEOGRAPHIC REGION

The following four geographic regions in the study area have been identified:

1. Southwest - Serviced by truck via MacKenzie Highway and CN rail line from Alberta.
2. West Central - Communities on the MacKenzie River not serviced by road, but accessible by barge from Hay River.
3. North West - The area around Inuvik, serviced by the Dempster Highway via Yukon Territories and B.C. from Alberta; Alternative connections to Hay River via barge.
4. North Central - Communities in the North serviced by barge from Hay River/Inuvik.

These geographic regions are shown in Figure 2.1.

A summary of waste oil generated by geographic region is shown in Table 2.1 below:


SERVICE AREA
**POPULATION
(1985 est.)**
FREIGHT SERVICE BY:

- | | | | |
|--|----------------------|--------|---|
| 1.  | SOUTHWEST | 22,316 | TRUCK VIA MACKENZIE HIGHWAY
CNR TO HAY RIVER |
| 2.  | WEST CENTRAL | 2,756 | BARGE FROM HAY RIVER |
| 3.  | NORTHWEST | 6,031 | TRUCK VIA DEMSTER HIGHWAY
BARGE FROM HAY RIVER |
| 4.  | NORTH CENTRAL | 3,610 | BARGE FROM HAY RIVER/INUVIK |

Figure 2.1
SERVICE AREAS /
TRANSPORTATION REGIONS

TABLE 2.1
WASTE OIL GENERATED IN THE WESTERN NORTHWEST TERRITORIES

<u>Region</u>	<u>Waste Oil (L/a)</u>	<u>%</u>	<u>Contaminated Fuel (L/a)</u>	<u>%</u>
Southwest	1,087,685	66	150,380	96
West Central	83,355	5	-	-
North West	445,503	27	5,800	4
North Central	31,952	2	-	-
Total	1,648,495	100	156,180	100

Oil exploration is not included in these figures for the following reasons:

- o Oil exploration has come to a temporary standstill because of the low world price of oil and questionable economics of drilling for new oil at this time. Although Gulf has indicated that some activity is foreseen in the near future, exact figures that would reflect waste oil production were not obtainable.
- o The oil companies have already established methods of disposing of their own oil. These include:
 - Burning waste oil for heat on board the ships
 - Incinerating contaminated fuels in a Saake burner
 - Dust supression on shore
 - Corrosion protection for drill pipe

Exact quantities of the oil used for the above purposes were not obtainable.

When exploration activities are in full swing, up to one million litres of waste oil and about 0.7 million litres of contaminated fuel can be anticipated. The extent of drilling and production activities will largely determine the amount of waste oil available. Presently, and for the next 4-5 years, oil exploration should not be considered a major generator of waste oils, but it should be perceived as having great potential, should the world price of oil so dictate.

Separate tables showing total quantities of waste oils and contaminated fuels generated by region are presented at the end of this Section (Tables 2.3 to 2.6). Quantities are shown for each community, with a separate category for oil from vehicles, which was calculated for the whole region. The basis for the calculation of waste oil from smaller communities and from vehicles is presented in Table 2.7 at the end of this Section.

Initial survey results for the major communities were compiled and individual tables prepared. These tables are attached in Appendix 2.

2.3 WASTE OIL GENERATION BY PRODUCING CATEGORY

Eight major waste oil producing categories were defined, and quantities tabulated accordingly in Table 2.2.

The largest producer of waste oils is the road transportation category (56%), followed by marine transport (15%), electrical generation (10%) and mining (8%). The remaining 11% comprise oil production, construction, air transport and public works.

Oil exploration is mentioned, but excluded from calculations for the reasons described under 2.2.

Over three-quarters of the contaminated fuels originate from marine transport. The barge companies are the major distributors of fuel in the NWT and substantial quantities of fuel are contaminated when the tanks are cleaned, and when the tanks must be emptied for repair or for other unusual reasons. The oil that cannot be reclaimed for use as fuel is called "slops." Slops generally have a very high water content (up to 60%).

TABLE 2.2
WASTE OIL SUMMARY BY PRODUCING CATEGORY

<u>Category</u>		<u>Lube Oil (L/a)</u>	<u>Contaminated Fuels (l/a)</u>
A.	Marine Transport	249,000	119,500
B.	Air Transport ^{1 2}	37,800	5,580
C.	Industries: Oil Producing	57,200	-
	Oil Exploration ³	(1,000,000)	(700,000)
	Mining	132,600	-
D.	Services: Electrical Generation	168,800	-
	Dept of Highways/ Public Works	26,000	-
E.	Bulk Fuel Plant	-	27,500
F.	Highway & Heavy Construction ²	51,300	-
G.	Trucking (long distance) ⁵	469,600	3,600
H.	Automobiles, Light/Medium Duty Trucks, Buses, Taxis ⁵	<u>456,200</u>	<u>-</u>
Total (Without Oil Exploration)		1,648,500⁴	156,180

¹ For smaller companies not surveyed, 100 L/aircraft/year were assumed.

² For smaller communities, where data was not available, the following assumptions were made:

- waste oil generated by the air transport industry amounts to 0.5 L/inhabitant/year
- waste oil generated by off road vehicles, construction equipment and from other sources amounts to 1.5 L/inhabitant/year.

³ Quantities shown are maximum based on Gulf, Dome and Esso actively exploring for oil in Beaufort Sea area, but not included in summary.

⁴ All figures rounded to the nearest 100.

⁵ Calculation assumptions are presented in Table 2.7.

2.4 ESTIMATE OF RECOVERABLE WASTE OIL QUANTITIES

In the "Program Guide to Used Oil Recycling" published by the Department of Energy in the United States in January, 1982 (DOE/CS/40402-1), the following relationships were established:

Of the total lubricating oil sold in the U.S., about half is consumed in use, discarded with the filter, or lost through leakages. The other half is termed "collectable used oil."

Of the collectable used oil:

- 53% is burned as fuel
- 6% is re-refined
- 41% is dumped (includes road oiling)

An EPA report, "Composition and Management of Used Oil Generated in the United States" (1985), EPA PB85-180297, agrees with the collectable used oil estimate. Their breakdown of the collectable quantities:

- 48.9% is burned as fuel
- 8.8% is re-refined
- 2.9% has a non-fuel industrial use
- 5.7% is used for road oiling
- 33.7% is dumped, landfilled or incinerated

In both studies, the amount of collectable oil actually used for re-refining or burning is about 60%.

In Canada, accurate waste oil quantities are more difficult to verify. It can be assumed that, as in the U.S., about one-half of the lube oil sold is theoretically collectable. Based on this, the estimated recovery rates of collectable oils range from 95% in B.C., 40% in Manitoba and Saskatchewan, to 20% in Alberta.

Of the 22 companies surveyed in the NWT, 13 indicated that some or all of their waste oil could be made available for recycling. This represents about 67% of

the total waste oil generated by the surveyed companies. Since most of these companies are larger, wastes are more controlled and would be more accessible than from small companies. It was found that smaller establishments use most of their oil for dust suppression and heating.

17% of all used oil was reported to be used for heating purposes and 12.5% for dust suppression. These figures are considered to be on the low side, especially the quantities involved in dust suppression. Oiling roads, yards and driveways is common practice in the NWT and it is estimated that at least 20% of the waste oil is used in this manner.

The quantity of oil used for heating purposes does not include the municipal water heating project presently under construction in Hay River, which will use up to 300,000 L waste oil per year.

A significant amount of waste oil, estimated at 10%, is used to train fire fighters.

A summary of waste oil collectable and its current disposition is presented below:

Used Oil Available	1,650,000	L/a
Contaminated Fuel Available	<u>150,000</u>	L/a
Total Waste Oil Collectable	1,800,000	L/a
Quantity Used for Heating (17%)	306,000	L/a
Quantity to be Used in Hay River Project	300,000	L/a
Quantity Used for Dust Supression (20%)	360,000	L/a
Quantity Used for Fire Drills (10%)	<u>180,000</u>	L/a
Total Waste Oil Recoverable for Re-Refining or Other Heating Projects	654,000	L/a

The total waste oil recoverable represents 36% of the waste oil collectable.

If the quantity of oil used for dust suppression is reduced by 50%, the amount of recoverable waste oil would increase to 834,000L/a or 46% of the waste oil collectable. Since the use of waste oil as a dust suppressant is undesirable from an ecological point of view, it has been assumed that its use will be reduced.

For the purpose of this study, the recoverable waste oil is 834,000 L/a or 46% of the waste oil collectable.

TABLE 2.3
WASTE LIQUID PETROLEUM SUMMARY BY REGION

Southwest Region

Community	Population¹	Waste Oils L/a	Contaminated Fuels L/a
Yellowknife	11,077	182,000	6,600
Hay River	3,190	135,055	135,500
Fort Smith	2,468	13,390	5,580
Pine Pint	1,759	5,800	-
Rae/Edzo ²	1,481	2,960	-
Fort Simpson	1,102	25,300	2,700
Fort Providence ²	663	1,330	-
Fort Liard ²	397	3,460	-
Others	179	360	-
Subtotal³	22,318	369,655	150,380
Cars & Trucks & Buses ²		348,341	
Tractor Trucks ²		369,689	
Total for Region		1,087,685	150,380

1 1985 estimate from NWT data book 1986-87.

2 Calculated consumption as per Table 2.5.

3 Subtotals do not include waste oil quantities generated by vehicles. These are calculated separately for the entire region as outlined in Table 2.5.

"-" Indicates no quantities available, or zero quantity is assumed.

TABLE 2.4
WASTE LIQUID PETROLEUM SUMMARY BY REGION

West Central

Community	Population¹	Waste Oils L/a	Contaminated Fuels L/a
Norman Wells	749	65,640	-
Fort Good Hope ²	693	2,790	-
Fort Franklin ²	589	3,660	-
Fort Norman ²	299	2,610	-
Snowdrift ²	270	1,510	-
Wrigley ²	<u>156</u>	<u>1,220</u>	-
Total³	2,756	77,430	-
Cars & Trucks ²		<u>5,925</u>	
Total for Region		83,355	-

1 1985 estimate from NWT data book 1986-87.

2 Calculated consumption as per Table 2.5.

3 Subtotals do not include waste oil quantities generated by vehicles. These are calculated separately for the entire region as outlined in Table 2.5.

"-" Indicates no quantities available, or zero quantity is assumed.

TABLE 2.5
WASTE LIQUID PETROLEUM SUMMARY BY REGION

North West

<u>Community</u>	<u>Population¹</u>	<u>Waste Oils L/a</u>	<u>Contaminated Fuels L/a</u>
Inuvik	3,166	92,950	5,880
Tuktoyaktuk	882	149,000	-
Aklavik ²	758	4,850	-
Fort McPherson ²	693	3,520	-
Tungsten ²	409	820	-
Actic Red River ²	<u>123</u>	<u>330</u>	<u>-</u>
Total³	6,031	251,470	5,880
Cars & Trucks & Buses ²		94,132	
Tractor Trucks ²		<u>99,901</u>	
Total for Region		445,503	-
Additional Quantities if Oil Exploration Active		Approximately 1,000,000	Approximately 700,000

1 1985 estimate from NWT data book 1986-87.

2 Calculated consumption as per Table 2.5.

3 Subtotals do not include waste oil quantities generated by vehicles. These are calculated separately for the entire region as outlined in Table 2.5.

"-" Indicates no quantities available, or zero quantity is assumed.

TABLE 2.6
WASTE LIQUID PETROLEUM SUMMARY BY REGION

North Central

<u>Community</u>	<u>Population¹</u>	<u>Waste Oils L/a</u>	<u>Contaminated Fuels L/a</u>
Cambridge Bay ²	902	9,750	-
Coppermine ²	887	6,280	-
Gjoa Haven ²	663	2,740	-
Spence Bay ²	452	2,680	-
Holman ²	345	1,770	-
Paulatuk ²	200	510	-
Sachs Harbour	161	460	-
Subtotal³	3,610	24,190	-
Total Cars & Trucks ²		7,762	-
Total for Region		31,952	-

1 1985 estimate from NWT data book 1986-87.

2 Calculated consumption as per Table 2.5.

3 Subtotals do not include waste oil quantities generated by vehicles. These are calculated separately for the entire region as outlined in Table 2.5.

"-" Indicates no quantities available, or zero quantity is assumed.

TABLE 2.7
BASIS FOR CALCULATED WASTE OIL QUANTITIES

Table 2.7-1
Formula for Estimating Smaller Communities'
Waste Oil Production (Annual)

Waste oil quantities from smaller communities are a summation of the following three categories:

- (a) waste oil produced by NCPC
- (b) waste oil produced in the community by "off-road" vehicles, construction equipment, and aviation services *
- (c) large industry waste oil (if any)

It has been assumed that Category (b), waste oil produced in the community amounts to approximately 2 L/person/year.

* Note: Road vehicles are accounted for separately. The formulas for the calculation of waste oil from vehicles is presented in Table 2.7-2 (Page 16) and the distribution of this waste oil to the four study regions is presented in Table 2.7-3 (Page 17).

Table 2.7-2
Total Calculation of Waste Oils From Vehicles

Vehicles producing waste oils are divided into two groups:

- (a) Automobiles, taxis, light and medium duty trucks, and buses
- (b) Tractor Trucks

(a) Automobiles, Taxis, Trucks, Buses

- Assumptions:
- Automobiles and trucks change oil twice a year
 - Average oil change is 5 L for automobiles
 - Average oil change is 15 L for buses and light trucks

Automobile & Taxi Registrations* =	7,012 (1985)
Truck & Bus Registrations* =	12,868 (1985)
Total Annual Crankcase Oil From Autos =	70,120 L
Total Annual Crankcase Oil From Trucks =	386,040L
Total Quantity of Crankcase Oil Per Year	
For Cars, Trucks, Buses =	456,160L

* (From NWT Data Book 1986-87)

(b) Tractor Trucks

All larger companies that drive into Alberta have maintenance shops in Alberta, and do most of their oil changes in Alberta.

- Assumption:
- 50% of crankcase oil is changed in NWT
 - Oil changed once per month @ 12 Gal or 55 L

Tractor Truck Registrations:*	1,423
Total Quantity of Crankcase Oil Per Year =	469,590L

Table 2.7-3
Formula for Distribution of Crankcase Oil Quantities:

In order to distribute the crankcase oil quantities calculated above to the various regions, it was decided to do this based on population densities.

- Assumptions:**
- o Waste oil from cars, trucks, buses
 - 97% is evenly distributed in road accessed areas
 - 3% is evenly distributed in areas without road access
 - o Waste oil from tractor trucks
 - 100% is evenly distributed in road accessed areas

Total Population Study Area*:	34,713
Population in Road Accessed Area:	28,394
Population in Areas Without Road Access:	6,364
Total Waste Oil From Cars, Trucks, Buses:	456,160L/a
Total Waste Oil From Tractor Trucks	469,590L/a

Based on the above assumptions and figures, the specific waste oil quantities per person/year were calculated and amount to:

- 15.6 L/person/year from cars, trucks, buses in areas with road access
- 2.2 L/person/year from cars, trucks, buses in areas without road access
- 16.6 L/person/year from tractor trucks in areas with road access

Table 2.7-3 continued

When the specific waste oil quantities per person/year are multiplied by the population of the four regions, it results in the following distribution:

<u>Region</u>	<u>Waste Oil From Cars, Trucks, Buses (L/a)</u>	<u>Waste Oil From Tractor Trucks (L/a)</u>
South West	348,341	369,689
West Central	5,925	-
North West	94,132	99,901
North Central	<u>7,762</u>	<u>-</u>
Total	456,160	469,590

3.0 USED OIL PROCESSING AND RE-USE

3.1 RE-REFINING PROCESSES

3.1.1 General

In the re-refining process, contaminants are removed from the used lubricating oil, (including the spent additive package) and the oil is returned to a base stock. This base stock can then be used for a number of purposes: remixed with additives to make a new lubricant; with different additives the material can be used as transmission oil, hydraulic oil, or chainsaw oil. A number of re-refiners in British Columbia are utilizing some of this oil (again, with the appropriate additives) as a dormant fruit spray. Mohawk Lubricants uses a base stock with additives as an effective dust suppressant on roads.

3.1.2 Present Operations

(a) Ontario

Two of the largest re-refineries in Canada - Breslube in Breslau, Ontario and Canadian Oil in Toronto are located in Ontario. Breslube is currently the largest operation in Canada. The maximum throughput is approximately 45 million litres per year; the capital cost for installation of this facility is in the order of \$12 Million. The Canadian Oil Re-refinery has a maximum throughput of approximately 30 million litres per year.

It is understood that the operation of the Canadian Oil Re-refinery is uneconomic at current oil prices. The Province of Ontario recognizes the economic problems currently facing the re-refining industry and it is anticipated that requests for financial aid might be received in the near future.

(b) Manitoba

There are no re-refiners in the Province. Most oil collected is sold to re-refiners in other provinces or to major burners in the U.S., but shipments to the U.S. have been much reduced because of the position taken by the U.S. Environmental Protection Agency on burning waste oil. Manitoba has one major collector and three smaller collectors of used oil.

(c) Saskatchewan

There is one re-refiner in the Province: Magnum Oil located in Saskatoon. It is a small, one-man operation and between 300,000 and 350,000 litres per year are processed.

(d) Alberta

Alberta has two re-refineries - Hub Oil in Calgary and Turbo Resources in Edmonton. Each re-refinery has a capacity of approximately 16 million litres per year. Hub Oil produces some lubricant for sale into the automotive market; however, the major market for each re-refiner is in producing oil for fleet vehicles, primarily the railroads.

(e) British Columbia

It appears at the present time that the prospects for continuing viable oil re-refining operations are in British Columbia. Mohawk Lubricants operates a modern re-refinery in North Vancouver with a capacity of approximately 35 million litres per year. It is vertically integrated, capable of utilizing internally the oil collected by its own collection service. Primary production is used as a lubricant under the Mohawk label.

In addition to Mohawk, there are a number of small re-refiners or reprocessors which reprocess the old oil to produce a dormant fruit spray, upgrade the oil for burning as a fuel, or clean up the oil for use as a dust-

suppressant. One processor cleans up the oil and sells it as a dormant fruit spray or as a lubricant for chainsaws. It appears that the market for dormant fruit spray is local and is best served by the local re-refiners or reprocessors.

3.1.3 Re-refining Technologies

(a) Acid-Clay Process

The acid-clay process is used extensively in re-refining. The used oil is passed through grids and screens to remove debris, and passed through a separator to remove free water. The oil is dehydrated at 150°C at atmospheric pressure.

In the acid clay process, the oil is dewatered, heated and then mixed with sulphuric acid that might be in concentrations of 50% - 90% (w/w), depending on the process. Coagulation occurs in 24 to 48 hours and the acid sludge containing the contaminants is drawn off (Technical Report CERL TR-N).

The clay treatment removes light fuel fractions, mercaptans and colour from the oil. The process temperature is 300°C and takes approximately 15 hours. The oil is filtered through a filter press and stored, with the addition of appropriate oil additives.

Advantages

The technology is well known and relatively inexpensive, and small units can be manufactured and operated. (The Magnum Oil re-refining operation in Saskatoon, with an annual output of 300,000 to 350,000 litres, uses this process, in addition to the two re-refineries in Alberta).

Disadvantages

Relatively large volumes of acid sludge are produced, at an estimated volumetric rate of 10% of the oil feed rate (Technical Report CERL-TR-N, N-133). The sludge contains concentrated sulphuric acid and lead. In addition, a large proportion of the sludge (30-50%) is soluble in water. Although the sludge is combustible, it should not be burned because of the potential generation of high concentrations of sulphur and metal containing particulates.

Appropriate disposal of this acid sludge could be expensive. (In Alberta, this material may be treated at the Swan Hills Hazardous Waste Treatment Facility).

The spent clay comprises 20% - 50% oil and disposal should be relatively easy.

(b) Vacuum Distillation

The process consists of three steps: pretreatment, distillation, and finishing.

Pretreatment is dehydration of the oil by heating to 150°C at atmospheric pressure to remove water. The water is mixed with caustic and naptha to break up oil-water emulsions, and precipitate solids.

Distillation is at 370°C and a vacuum of 27 in. of Hg (680 mm of Hg). The overhead stream is used as plant fuel.

The bottoms from the still may have an ash content as high as 10 to 25 percent, depending on the extent of pretreatment and feed stock characteristics. The bottoms are also higher in sulfur, nitrogen, oxygen and acidity than the feed stock. Lead is concentrated in the bottoms which may have a lead content of 5 to 15 percent.

The middle cut or "lube distillate" is put through to a finishing process (caustic clay treatment or hydrotreatment) prior to storage as lube oil.

Advantages

The distillation process has an advantage in that more than one "cut" may be taken off the middle of the distillation tower to produce several different oil products with different viscosities. A 70 percent yield may be expected - similar to that from an acid-clay process. Product quality is comparable to the acid-clay process.

(c) Phillips Re-Refined Oil Process (Report CERL-TR-N-135)

The Phillips Petroleum Co. has developed the Phillips Re-Refined Oil Process (PROP). It is understood that modular, skid-mounted PROP units are available that can treat 9, 22 and 45 million litres per year.

In the process, diammonium phosphate is mixed with heated oil to remove the metals. Metallic phosphates are formed and removed by filtration. Trace inorganics are then removed by mixing the oil with hydrogen, percolating it through a bed of clay, and passing it over a nickel molybdate catalyst.

The heated oil is flashed off, cooled and stripped to remove any light oils. It is understood that the process recovers 90% of the waste oil containing less than 10 ppm metals.

Wastes from the process include the filter cake from the metal removal process and some waste water which may require no further treatment.

This type of plant has a higher capital cost than that using the acid/clay treatment process and there are minimum size limitations in contrast to the acid-clay process.

3.1.4 Constraints

(a) Market Availability

The re-refiners in Canada are experiencing economic difficulties. Re-refined base stock has never made significant in-roads into the large lubricating oil market. The primary market continues to be the fleet market, and the railroads. When crude oil prices are low there is significant competition from virgin lube stock; Re-refined oil still has basic costs associated with collection. Markets for used lube oil were stable for a number of years and it is only recently that prices have fallen dramatically, with the drop in the price of crude oil.

There are two categories of users who might potentially be interested in purchasing oil from the Northwest Territories. These are the re-refiners and the burners. The oil collector or broker could also be considered but the sale would ultimately be to the same markets.

The re-refiners represent, by far, the biggest market. Burning of used lube oil is not a significant use in Canada although a major development is currently in progress in Hay River.

If the material is going to be sold to markets in Southern Canada, stockpiling becomes necessary. In general, the more material available, the more interested the southern markets become in it.

(b) Market Acceptability

Re-refiners have experienced difficulty in obtaining warranty approval for re-refined oil. Tests carried out on the oil shows that it is of similar quality to "virgin" oil. However, the major market has been reluctant to use re-refined base stock. Canadian Oil has marketed re-refined oil under the White Rose label. Hub Oil markets re-refined oil under the name of Lubey-Lube and Mohawk under its own name.

It is not required in Canada that it be stated on the label that the material is re-refined oil. In spite of this, major blenders and marketers have been extremely reluctant to use re-refined stock, preferring virgin stocks instead.

If a reasonable market for such oils could be sustained in the Territories, it might be possible to direct some of the material to markets in Southern Canada.

(c) Collection

Re-refiners have generally established collection systems. In the past, re-refiners accepted and/or paid for used lubricating oil delivered to the plant. In some cases, the re-refiners purchase oil from used oil collectors who supply an "emptying" service to service stations; in other cases, the re-refiners collect their own material.

Until the early 1970s, used oil was only available from service stations. If service stations included the price of an oil change with the price of the oil, there was no financial incentive for an individual to change his own oil. Some oil was always sold by retail firms such as automotive specialty shops, but this tended to be a specialty oil sold at a premium price. This, coupled with the low purchasing power of such shops, led to the oil being equivalent if not higher-priced than that sold in service stations.

Significant changes occurred in the early 1970s with the introduction of sales of lubricating oil by the mass marketers.

A department store purchasing on a nation-wide basis was able to purchase oil at a price significantly lower than that of the average service station. In addition, the oils typically sold by the mass market are not specialty oils, but tend to be the same sold by the service stations. These facts, coupled with the fact that the mass marketers did not incorporate into their price a service cost for an oil change (nor the inherent disposal fee of

the lubricating oil drained out of the vehicle), resulted in substantial undercutting by the mass marketers in terms of price and oil sold. There was now a substantial incentive for automobile owners to change their own oil.

It is difficult to develop a collection system when there is market uncertainty. The potential exists for a significant stockpile of re-refined oil while the market re-adjusts, or a significant disposal problem should the market collapse. These possibilities should be taken into account in developing the collection program. Sales to outside external markets can provide the mechanism to develop more local markets. Development of a market requires the material, which in turn needs the market to drive the collection system.

The actual amount of material necessary will be dependent upon the transportation method chosen, and the market that the material will satisfy. In addition, if the collection facility is privately operated, then consideration must be given to cash flow with respect to pick-up frequency, storage and re-refining.

If oil were shipped from the Northwest Territories and to southern markets, then consideration should be given to removing water prior to shipment.

Re-refined oils could also include hydraulic oils and transmission oils. The area that seems to offer the most potential is in cutting oils, and other oils used in "loss" applications (where the lubricant is consumed and not recoverable).

(d) Waste Disposal

If re-refining in the Northwest Territories is going to be considered as an option, disposal of waste requires careful consideration, particularly if the acid-clay process is used.

3.2 WASTE OIL AS FUEL FOR HEATING

3.2.1 General

If large scale burning of used lube oil is to be considered as an option, it is necessary to "clean-up" the lube oil prior to it being used as a fuel. This facility would remove the water from the oil and filter the oil to improve it.

The amount of fuel that is required for a given operation may be reduced by the use of lube oil as a fuel. Small scale burners which can serve the size of garages or maintenance shops are available. An alternative could be to bulk the oil for use as a fuel to heat public buildings. These two options are not mutually exclusive, and may be complementary in some cases.

There are a number of major points to be taken into account (U.S. Army Corps of Engineers, Tech. Report N-135) underlying a used oil burning system:

- o Lead pollution from emissions (from the tetra-ethyl lead used as an "anti-knock" agent in gasoline).
- o Potential for explosions from lighter fractions having differing flashpoints.
- o Build-up of contaminants in pipes.
- o Potential for freezing of feed lines in cold weather due to moisture in the fuel.

The authors of this report (N-135) recommended that if burning were the chosen method:

- o The lead content of the fuels should be calculated and lead emissions assessed (20-100% of lead is emitted).
- o The fuel should be treated after settling to remove water and particulates, which can be achieved by screening, centrifugation, filtration, distillation and chemical treatment.

It is estimated (EPA Report PB 85-180297) that 50% of waste oil generated is burned as a fuel, or 73% of collected waste oil in the United States. The authors noted that facilities designed to burn No. 6 fuel oil and most facilities designed to burn No. 4 and No. 5 fuel oils can burn straight used oils. Blending dilutes the concentration of contaminants and provides a more constant material. In general, the authors found that most used oils were pre-processed prior to burning as fuel.

These figures contrast with the situation in the Province of Alberta, where very little used oil is burned.

3.2.2 Technology

As discussed previously, used lube oil can be burned in most facilities designed for burning No. 4, No. 5 or No. 6 fuel oil. There are no special designs or technologies required for burning the used oil as a fuel; the principle consideration is the appropriate type of burner that is very dependent on the viscosity of the used oil.

Primary requirements are a burner and heat exchanger that are compatible with the fuel. Potential air emissions are a concern in a used oil heating system and provisions must be made in the design for the installation of air monitoring equipment (for example, continuous stack emission monitors) and for the installation of air pollution control equipment if this is considered necessary or desirable.

Pretreatment of the used oil is necessary for the removal of solids and water to avoid problems in burning the oil and to minimize the formation of sludge and tank bottoms in the used oil storage containers. Water can be separated from the oil using a demulsifier followed by centrifugation to remove the solids and residual water prior to storage and burning of the oil.

An air gun burner comprises a fixed orifice nozzle where a whirling conical spray is produced and air is swirled concentrically with the fuel to provide combustion. It is suitable for small installations and relatively light waste oil.

Fuel atomizers using high pressure steam or high pressure mechanical systems are used in relatively large installations. The nozzles are designed to provide sufficient atomization of the oil. The nozzles are easily plugged and therefore in this type of installation it is necessary to remove particulates from the oil.

Rotary cup burners use centrifugal force to atomize the oil, which is thrown off the rim of the cup as a thin film. The oil is atomized using a concentric stream of air.

Disposal of Residues

Residues for disposal include the water associated with the used oil prior to treatment, sludges, tank bottoms and boiler ash residue.

Waste water residue from the oil may be in the order of 10 to 20 percent of the used oil collected and further treatment prior to disposal may be required. The water could contain organic solvents and low concentrations of heavy metals may remain in the water due to residual oil associated with the water.

Disposal of sludges and tank bottoms might be possible by incineration, but installation of a small incinerator for this purpose alone would be costly.

Residue from the boiler may be considered non-hazardous and is relatively easy to dispose.

3.2.3 Constraints on Burning Waste Oil as a Fuel

Because of the lead content in gasoline, there is some concern regarding the use of used lubricating oil as a fuel. More recently, the U.S. Environmental Protection Agency has banned the use of used lubricating oil as a fuel in

facilities without adequate pollution control equipment. A similar ban is currently being considered by a number of provinces and the Canadian Department of Environment.

Used lubricating oil has not had a significant effect on the fuel market, particularly in Western Canada. There are a number of greenhouses in the interior of British Columbia which burn used lubricating oils for heating. In the Maritimes, some used lubricating oil is still used for heating by garages and other large generators. Similar situations apply in Quebec and Ontario.

Some burning takes place in Manitoba, and there is very little in Saskatchewan and Alberta. This may be because of re-refineries in the province and the predominance of natural gas for heating. The conversion from fuel oil heating to used lubricating oil is relatively inexpensive. The conversion from natural gas heating to used lubricating oil heating is relatively more expensive, and generally requires a new furnace rather than only a change in burner jets.

In the late 1970s, the state of Alaska was considering a state-wide collection and bulking system for used lubricating oil. There was consideration that the oil would be collected in communities and used during the winter to heat public buildings. The state was also encouraging the burning of used lubricating oil by generators, such as service stations, for heating their own premises. This has been affected by the ban on burning by the Environmental Protection Agency. Currently, some oil generated in Alaska is being sold to re-refiners in southern Canada.

Furnaces in general require a consistent quality fuel for best thermal efficiencies and maximum heat production. One of the problems with using used lubricating oil as a fuel is the variation in consistency. An example of one of the problems is water: typically, used lubricating oil contains approximately 15 percent water. However, used lubricating oil that has sat for some significant period of time will contain less water primarily because the oil and water have been allowed to separate.

Another commodity commonly found in used lubricating oil is solvent. The addition of solvent into a furnace designed to burn used lube oil could result in fire or explosion and fire. In addition, the byproducts associated with combustion may vary from batch to batch of used lubricating oil and flue gas scrubbing could be difficult.

These factors led to relatively little used lubricating oil being used as a fuel; however, the development of the used oil burning system in Hay River is a notable exception. The Federal Department of Environment is involved in this work and the design of the system will incorporate a monitoring system for air emissions in order to assess the impact on air quality of the operation.

3.3 OTHER USES OF WASTE OIL

Very few other uses of waste oil are common; the major ones are:

- Dust Suppression
- Corrosion Protection

3.3.1 Dust Suppressant

The use of waste oil as a dust suppressant is generally being discouraged by authorities in North America. It has been recognized that contaminants in the waste oil can quickly leach out and contaminate surrounding areas and endanger groundwater supplies.

This use of waste oil was not recommended by the authors reviewing the re-use of waste oil at U.S. Army installations (U.S. Army Corps of Engineers, Tech. Report).

According to the authors of a recent report prepared for the U.S. Environmental Protection Agency (EPA PB 85-180297), it was estimated that approximately 6%

of used oil generated in the United States is used for oiling roads, with higher percentages in some sparsely population regions.

In Alberta, approximately 5% of lube oil sold or 6% of waste oil generated is used for road oiling, based on the report: "Recycling in Alberta - An Outline (1979).

The use of waste oil for dust suppression is constantly shrinking.

3.3.2 Corrosion Protection

This is by far the least common application of waste oil. Oil companies have been known to protect drill pipe with waste oil. Some farmers use it to protect metal equipment.

The quantities of waste oil used for this purpose are estimated to be minimal and of no consequence for the purpose of this study.

4.0 APPROACH OF THE PROVINCES

4.1 PROVINCE OF ONTARIO

4.1.1 Regulation

Under Regulation 309, used lubricating oil has been designated a hazardous waste. Only those carriers designated as hazardous waste carriers are authorized to carry used lubricating oil. Re-refining operations are regulated under existing environmental legislation.

4.1.2 Quantities of Used Oil

Ontario does not keep separate records on used lube oil collectors, but it is estimated that approximately one-half of hazardous waste carriers transport used lube oil.

Records on oil collection are not maintained and the Ministry of Environment is currently carrying out a study to determine the use of oil being collected. Initial estimates indicate that 50% of the oil collected goes to the re-refiners and 50% to other uses, including burning, road oiling, etc. There is a number of firms cleaning the used oil and selling it in the Maritimes and the U.S. for burning.

The Province of New Brunswick has expressed some concern about the contaminants in the oil and is currently requiring testing on all oil brought into the Province for burning. Since local waste oil does not have to be tested, it has become more attractive to collect local waste oil and utilize it for burning, than to import it from other provinces.

4.1.3 Collection Programs

The Province of Ontario has not undertaken any major initiatives to collect used lubricating oil. The Province provides funding for curbside collection programs, in which a variety of materials are collected at curbside, and in a manner similar

to garbage collection. Typical materials collected include newsprint, glass, metals and, in many projects, oil.

In Kitchener/Waterloo (a program run by Total Recycling - a division of Laidlaw), oil is collected at curbside in conjunction with a variety of other materials. The oil is placed in racks beneath the trucks and emptied into a small tank at the collection site. The amount of oil generated by such programs is small, but there is the potential of capturing a large percentage of oil from the 'do-it-yourself' market, that is, individuals who change their own automobile oil.

Environment Canada set up a pilot collection program involving 500 service stations in the most densely-populated areas of the province - the so-called "Golden Horseshoe" in Southern Ontario. Signs were placed at service stations indicating where the public could leave waste oil.

There were a number of problems encountered, including signs being removed, spillage, and service stations withdrawing from the program without notification. This program is now run by an organization called Pollution Probe.

4.2 PROVINCE OF MANITOBA

4.2.1 Regulations

Regulations specific to used lubricating oil have not been developed at the present time.

4.2.2 Quantities of Used Oil

It is estimated that sales of lube oil in the province amount to 36 million litres. It is estimated that 7 million litres are recovered by collectors.

Manitoba has a large number of facilities burning used lube oil as a fuel. Most of these are service stations, fleet owners, or others who generate large quantities of used lube oil themselves.

4.2.3 Collection Programs

The Province discourages but does not prohibit used lube oil as a dust suppressant on roads. This approach is similar to that in other provinces. No other provincial initiatives are in place.

4.3 PROVINCE OF SASKATCHEWAN

4.3.1 Regulations

Used lubricating oil is regulated by the Department of Environment.

4.3.2 Quantities of Used Oil

The Department of Environment estimates that there are 12 used oil collectors (four major collectors and eight smaller collectors), operating only in the major urban areas of the province.

In rural Saskatchewan, the oil is disposed in pits at landfills, etc. The Province estimates approximately 16 million litres are collected each year. At present, the majority of the used oil is shipped to re-refiners, primarily those in Alberta. Because of the current economic problems facing re-refiners in Alberta, the collectors in Saskatchewan are having difficulty in selling all the used oil collected.

Used oil is used as a replacement for Bunker C fuel, by asphalt plants, and for dust suppression. The Department of Environment estimates these amounts to be relatively small.

4.3.3 Collection Programs

The Province has not moved into the area of encouraging returns on used lube oil, and the development of such programs will be dependent on improvement in the market for re-refined oil. Some consideration has been given to promoting the installation of tanks by municipalities for collection in rural areas, but its implementation will also depend on market improvement.

4.4 PROVINCE OF ALBERTA

4.4.1 Regulation

Used lube oil is exempted from the Hazardous Waste Regulation under the Hazardous Chemicals Act, if it is intended for reuse, reprocessing or recycling at a licensed facility. In this case, the used oil is exempt from provisions such as manifesting, etc. However, the waste residual from a re-refining facility might be considered a hazardous waste.

4.4.2 Quantities of Used Oil

There is some uncertainty in the volume of sale of lubricants; based on a 1974 report by Synergy West, annual sales were between 135 and 160 million litres and it is anticipated that current volumes would be within this range.

It is estimated that between 27 and 32 million litres (20% of use) is consumed in engine operation. In addition, 33 to 40 million litres is used in a "loss" situation (i.e., cutting oils, chain oils, etc.) or in long-term applications such as hydraulic or transmission oils). Thus there are potentially 75 to 88 million litres which could be collected.

4.4.3 Collection Programs

The Province has undertaken a number of initiatives to increase the amount of used lube oil being returned (for re-refining). The approach of the Province has been to recognize that there are two separate groups to be served:

In the urban areas, the concern is the home mechanic who changes his own vehicle oil. This market is significant, ranging from 15 to 50 percent of oil sold (taking into account demographic factors, locations of service stations in the area, price of oil, season, etc.).

In rural Alberta, the agricultural community is the second major generator of used oil after the services stations. In general, service stations have no facility for storage of oil in any quantity. Often it is not collected.

Volumes of waste oil and distances travelled are two areas of concern in implementing an effective program. A relatively long distance is travelled to collect a unit quantity of used oil compared to urban areas and thus collection is uneconomic unless the price of used oil is relatively high.

The Province provided grants to the municipalities to install tanks to store used lube oil in order to facilitate collection in small communities. These tanks are above the normal capacity of used lubricating oil collection vehicles. When the tanks are full, it is economic for either a collector or one of the re-refiners to collect the oil from the tanks.

Collection in Alberta is similar to that in British Columbia and steps taken by Environment Canada in Ontario. The Province has compiled a list of services stations in Alberta prepared to accept oil back from the public. There are approximately 300 such service stations in the Province, including 75 in Edmonton and 100 in Calgary. These stations display a black and gold decal identifying them as an "oil-drop" station.

A number of communities have also established collection systems that involve collection of the waste oil directly from the service station or farmer. Some of these systems are very successful. One system in the County of Flagstaff (southeast of Edmonton) collects in excess of 6,800 litres of oil per month.

4.5 PROVINCE OF BRITISH COLUMBIA

4.5.1 Regulations

The Province considers used lubricating oil as a hazardous waste, in a manner similar to the Province of Ontario.

4.5.2 Quantities of Used Oil

The B.C. Ministry of Environment estimates that approximately 97 million litres of engine lubricant is sold each year in the Province. It is understood that approximately 45% of that sold is collected as waste oil, amounting to 46 million litres.

4.5.3 Collection Programs

There are approximately 26 used oil collectors operating in the Province and Mohawk is the largest.

The Province adopted a program to convince service station operators to accept used lubricating oil back from the public:

Under this program, there are could be in the order of 100 to 200 service stations which accept oil back from individuals who change their own crank case oil.

The initial concept involved a small card on which locations were noted where the material could be returned. This card could be picked up when

the oil was purchased. This message was reinforced by signs at the service stations indicating where the oil could be returned.

Plans for radio and television advertisements for the program have been postponed due to budget constraints, and the program is no longer actively promoted. The Department maintains lists, on a regional basis, of service stations involved in the collection program.

5.0 POTENTIAL ALTERNATIVES FOR THE NORTHWEST TERRITORIES

The major technologies of waste oil recycling and uses of waste oil are described in Sections 3 and 4, as well as the approaches to waste oil by a number of the provinces. In this section, three potential alternatives in the NWT are examined in more detail.

5.1 ALTERNATIVE 1: COLLECT AND SHIP WASTE OIL TO RE-REFINERIES IN SOUTHERN CANADA

5.1.1 General

Two waste oil re-refineries that are accessible from the study area in the NWT are TURBO in Edmonton, Alberta and MOHAWK in Vancouver, British Columbia. Both have road and rail connections to Hay River and both are capable of handling the quantities of waste oil being generated in the NWT.

A collection and transportation system would be required. Waste lube oil from all sources would be collected locally, shipped to Hay River for storage, and then continue by rail or truck to one of the re-refineries.

5.1.2 Local Collection and Storage

Lubrication oils are generally distributed in 205 L (45 gal) drums. These drums could be utilized for the collection, storage and local shipping of waste oils.

In most smaller communities, lube and fuel oils are stored on tank farms, from where they are distributed. Waste oils could be returned to the distributor for storage in the 205 L drums. Tank farms would be a suitable storage location since the operators are experienced in handling oil with trained personnel, and the necessary dyking and fencing for spill prevention/containment are in place.

The majority of tank farms are owned by GNWT and the operation is contracted to private individuals. Some consideration of reimbursement might be considered, possibly on a ¢/litre basis, for handling and storage of the fuels.

The larger communities could possibly set up waste oil collection systems somewhat similar to those in Alberta. The smallest producers of waste oils could drop off their oil at designated collection points, possibly automotive service shops or oil distributors that already have a collection container. From these points, oil could be picked up by a tank truck at regular intervals and brought to a central storage facility.

The costs associated with this system are mainly for transportation and storage. Storage costs would depend on whether or not existing tanks would be available for use, or if new storage tanks would be required.

5.1.3 Transportation

There are two distinct transportation phases: Waste oil is shipped from each community to a central depot and then shipped to a re-refinery.

The barge system is the most economical form of transportation within the NWT, and for many communities the only form (excluding air). The main link between the barge systems and road/rail systems is in Hay River, and thus Hay River is a logical selection as the central waste oil depot.

Waste oil, stored in 205 L drums, could be picked up by the barges and transported to Hay River. Although the barges have holding tanks, these are used for virgin fuels and are not generally available for waste oil. Communities serviced by roads could utilize trucker's back-haul rates to get their waste oil to Hay River (if these are less expensive than barge rates).

The carrier selection for transporting the waste oil to the re-refinery depends on economics (truck back-haul rates vs. specially negotiated rates with CN) and on the destination. Edmonton, being closer to Hay River than Vancouver, has

advantages in terms of transportation costs. Re-refinery selection factors also depend on whether or not waste oil is being accepted for re-refining, and at what unit price.

5.1.4 Costs

The economics of re-refining oil are determined by the price paid for waste oil and by the cost of bringing it to market. The costs break down as follows:

- o value of the waste oil to its producer
- o local handling and storage
- o regional transportation to central depot
- o storage and transfer charges at central depot
- o transportation to re-refining

(a) Value of Waste Oil to its Producer

In general, companies contacted during the survey indicated that they would not expect payment for their used oil. However, in some cases, for example where the waste oil is used to replace fuel oil for heating, it has a value, and the waste oil would not be made available free of charge. Cost data were not obtainable and thus a numerical value could not be placed on this oil.

In Hay River, where a waste-oil fired heating unit is under construction for the municipal water system, it has been determined that all waste oil not required for other purposes, will be available to the Town free of charge.

The same assumption has been made in this study: **Waste oil available for recycling will have no monetary value (before pick-up).**

(b) Collection, Handling and Storage Costs

Estimates for the collection, handling and storage of waste oils vary greatly and are dependent on the size of the community.

For larger communities, the Hay River (Manecon Report, 1985) example should provide reasonably accurate figures for collection, pre-treatment and storage of waste oils. Costs estimated are based on 20% water contamination and break down as follows:

Collection:	\$0.008/L waste oil
Pre-Treatment:	\$0.038/L waste oil
Storage:	<u>\$0.005/L waste oil</u>
Total	\$0.051/L waste oil

The above costs exclude capital costs. It is assumed that collection will be subcontracted, and that existing treatment facilities and storage tanks can be used. Included are disposal costs for waste water residue, sludge disposal (if applicable), power, and labour. It is assumed that the oil will undergo some form of dewatering and filtering to make transportation more economical.

In smaller communities, where the operation of tank farms is contracted to private individuals, operating costs may range from 15¢ to 20¢/gallon or \$0.033 to \$0.044 per litre. Since no capital investment is required to return waste oil in drums, and pre-treatment will be minimal, it has been assumed that the cost of handling and storing waste oil in a smaller community will be in the \$0.03/litre range. Collection costs are not included since it is assumed that waste oils will be brought to the tank farm by their producer.

For calculation purposes, \$0.05/litre will be used.

(c) Transportation Costs

Two types of transportation costs are considered:

- 1) Regional - from the various communities to Hay River
- 2) Market - from Hay River to the re-refinery

It is assumed that regional transportation will be mainly by barge, and the following approximate rates will apply:

Within the Southwest Region, \$5.00/100 lbs, or 10¢/litre
West Central Region to Hay River, \$7.00/100 lbs, or 11.5¢/litre
Northwest Region to Hay River, \$10.00/100 lbs, or 16.4¢/litre
North Central Region to Hay River, \$20.00/100 lbs, or 32.8¢/litre

It is assumed that back-haul rates, more favourable than the ones used above can be negotiated with the barge companies.

From Hay River to Edmonton, the following rates were quoted:

Tank Truck (one-way rate)	6.4 ¢/litre
Tank Truck (Back-haul, when available)	3.4 ¢/litre
CN Rail, Tank Car (negotiable rate)	25 ¢/litre

From Hay River to Vancouver, the following rates were supplied by the transportation companies:

Tank Truck	12.5 ¢/litre
CN Rail, Tank Car	44.0 ¢/litre

The tank truck rate is composite, consisting of a one-way rate from Hay River to Prince George, B.C., and a back-haul rate from there to Vancouver. The CN rate is a regular one-way rate estimate and should be regarded as maximum. When quantities and frequency of shipments are known, these rates are negotiable.

(d) Value of Waste Oil to the Re-Refineries as Feedstock

The waste oil re-refining market is volatile. Prices depend on the quantities of waste oil available, and the demand for re-refined lube oil,

which in turn depends on the world price of crude oil. When the price of virgin oil is low, re-refined oil is not competitive because consumer preference is to use virgin oil. It appears that re-refined oil is sold approximately 20% below virgin oil price, and this seriously erodes the profits of the re-refiners when the price of crude oil is low and it is reflected in the price the re-refiners pay for waste oil feed stock.

Currently (early 1987), with crude oil at approximately U.S. \$18 per barrel, the Turbo re-refinery in Edmonton could pay about 4¢ per litre delivered, but is not accepting new suppliers or any additional oil over and above what they are receiving now, because of lack of markets for the re-refined product. The Mohawk re-refinery in North Vancouver is accepting waste oil delivered, but will not pay for this commodity.

COST SUMMARY
(¢/Litre)

	<u>Region</u>			
	<u>South West</u>	<u>West Central</u>	<u>North West</u>	<u>North Central</u>
Collection/Handling/Storage	5	5	5	5
Transportation to Hay River	10	11.5	16.4	32.8
Transportation to Edmonton(1)	3.4	3.4	3.4	3.4
Transportation to Vancouver(1)	12.5	12.5	12.5	12.5
Total Costs(1)				
Re-Refined in Edmonton	18.4	19.9	24.8	41.2
Re-Refined in Vancouver	27.5	29.0	33.9	50.3
Value of Waste Oil as Feed Stock (5% water Content)				
Turbo (Edmonton)	4	4	4	4
Mohawk (Vancouver)	0	0	0	0
Total Profit/(Loss)(1) When Re-Refining in:				
Edmonton(2)	- (14.4)	- (15.5)	- (20.8)	- (37.2)
Vancouver	- (27.5)	- (29.0)	- (33.9)	- (50.3)

(1) Most optimistic values used

(2) Turbo in Edmonton will not accept additional waste oil

5.2 ALTERNATIVE 2:

BUILD A WASTE OIL RE-REFINERY IN THE NORTHWEST TERRITORIES

5.2.1 General

The feasibility of building a re-refinery in the NWT is considered, taking into account the distances and associated shipping costs involved in bringing waste oils to markets in Southern Canada.

5.2.2 Location

There are three potential locations for a re-refinery.

A re-refinery in the Southwest region could be considered because this is the region of highest generation of waste oils. This region has the infrastructure to support the construction and operation of a re-refinery and it has the road and rail access to Alberta for supplying necessary chemicals.

Another potential location for the re-refinery is at Norman Wells. ESSO has a refinery at this location, shipping routes throughout the NWT are well established, and the necessary industrial infrastructure is also established. There is some indication of interest from ESSO in this type of project, depending on economic and other considerations. The disadvantage of the Norman Wells site is higher transportation costs for plant construction, supply of consumables and delivery of waste oil.

A third alternative is to locate the re-refinery in Tuktoyaktuk in anticipation of larger amounts of waste oil from the oil industry. Spokesmen for the oil companies in the North do not anticipate much activity in the Beaufort area for at least 4 - 5 years, so that Tuktoyaktuk does not seem a good choice at this time.

For the purpose of this study, a location in the Southwest region has been chosen. A site in the region of Hay River would have access to three modes of

transportation (water, rail and road) and it would be in the centre of the most populated region.

5.2.3 Local Collection and Storage

The comments on collection given in Section 5.1.2 apply here and there would be no difference in local collection and storage between re-refining in Hay River and re-refining in Edmonton or Vancouver.

5.2.4 Transportation

With a re-refinery in Hay River, only the regional transportation system, identical to the system used for the re-refining in Southern Canada alternative would be required. It is described in Section 5.1.3. Central storage facilities for the waste oil would be located at the re-refinery.

5.2.5 Costs

The cost picture changes substantially in this alternative compared to Alternative 1 (ship to a re-refinery in Southern Canada). In addition to collection, handling and shipping costs, there are operating and maintenance costs, and debt service costs. Revenues also increase, since a finished product can be sold (within the Territories).

(a) Collection, Handling, Storage and Transportation Costs

These costs will be the same as for the re-refining in Southern Canada Scenario, Section 5.1.4:

Collection and Handling	5.0¢/Litre
Transportation to Hay River From:	
Within South West Region	10.0¢/Litre
West Central Region	11.5¢/Litre
North West	16.4¢/Litre
North Central Region	32.8¢/Litre

(b) Capital and Operating Costs

Capital and operating costs are very difficult to assess and there is little cost information on existing re-refineries available. The following estimate was made in order to obtain order of magnitude costs.

Process Chosen: Distillation/hydrofinishing (this is the process used at the Mohawk re-refinery in Vancouver, which is operating successfully; it has less wastes sludges than the acid-clay process).

Capital Costs: A distillation hydrofinishing plant was recently completed in San Francisco. It has an annual capacity of 38 million litres and cost approximately U.S. \$12 million (1986 dollars) (Can \$16 million) to build. This includes tankage, but excludes land costs.

It is assumed that small distillation hydrofinishing plants can be built.

A maximum of 1.8 million litres/year, would be available if all the waste oil in the NWT were to be processed there, and 0.8 million litres per year would be available if only the recoverable waste oil were processed. Thus the maximum capacity of the re-refinery would be 1.8 million litres.

Assuming an optimistic value of 1.5 million litres/year, the plant would have 4% of the reference plant capacity. A power factor of 0.6 is applied to compensate for the downsizing, and a factor of 1.5 for the higher costs of construction of

a plant in the North. The resulting capital cost is close to \$3.5 Million. Based on discussions with industrial personnel, this capital cost figure appears too low, therefore a more realistic figure of \$4.5 million will be used.

Debt service on this amount, over a 20 year period amounts to approximately \$530,000 per year, at 10% interest per annum.

Operating Costs:

The distillation hydrofinishing process is a continuous process. Assuming three 8-hour shifts per day for two operators, and a plant operating 340 days per year, this amounts to:

$$16,320 \text{ hours/year} \times \$20/\text{hour} = \$326,400/\text{year}$$

Maintenance is assumed at 30% of operating costs or \$326,400/year.

Consumables, such as caustic for acid neutralization and heating fuels cannot be estimated at this time, and an assumed figure of \$250,000 will be used for calculation purposes.

Total Capital and Operating Costs

Debt Service	\$ 530,000/annum
Operating Costs	\$ 326,000/annum
Maintenance Costs	\$ 98,000/annum
Consumables	<u>\$ 250,000/annum</u>
Total	\$1,204,000/annum

Based on a plant capacity of 1.5 million litres per year, this amounts to 80¢/litre if the plant is running at full capacity. At 50% capacity, the costs per litre rise to \$1.44.

Revenue received from the sale of oil will partly offset the high plant costs.

It has been assumed that the re-refined oil can be sold for 30¢/litre, based on selling prices of TURBO in Edmonton and MOHAWK in Vancouver.

It is emphasized that only order of magnitude costs have been developed to indicate costs associated with building and operating a small capacity re-refinery.

COST SUMMARY (¢/Litre)

	Region			
	<u>South West</u>	<u>West Central</u>	<u>North West</u>	<u>North Central</u>
Collection/Handling/Storage	5	5	5	5
Transportation to Hay River	10	11.5	16.4	32.8
Re-Refining	<u>80</u>	<u>80</u>	<u>80</u>	<u>80</u>
Total Costs	95	96.5	101.4	117.8
Revenue From Sales	30	30	30	30
Profit (Loss)	- (65)	-(66.5)	-(71.4)	-(87.8)

5.3 BURNING OF WASTE OIL FOR HEATING PURPOSES

5.3.1 General

A concern in burning waste oil for heat generation is the emission of lead originating from leaded gasoline.

It is estimated that less than 10% of waste oils in the NWT contain lead (Table 5.1). The option of burning waste oils for heating fuel has some merit, considering the transportation distances between communities, the waste oil quantities generated, the harsh climate and resulting high requirement for heat.

In the United States it is estimated that one-half of the waste oil generated, or over 70% of the waste oil collected is burned as fuel (EPA Report PB85-180299).

5.3.2 Applications

Waste oil is already being burned as fuel by a number of establishments. Most units are small space heaters/furnaces, and are being used to heat service garages, hangars, and workshops. NCPC operates a boiler at Inuvik and blends the waste oils from their local diesel-generator into the bunker C that is being fired (approximately 57,000 L waste oil are consumed per year).

There is a major waste oil burning facility currently under construction at Hay River, and it will be used to heat the municipal water system in the winter. The system, which includes storage tanks and pre-treatment facilities, will burn approximately 275,000 litres of waste oil annually.

Larger systems, with their inherent economies of scale, are preferred for the following reasons:

- o larger systems make pre-treatment economically possible
- o emissions monitoring is easier to implement for large plants
- o control of waste oil remains with the government (for a government operated system)
- o organized collection will reduce waste oil quantities dumped
- o cost savings from replacing virgin oil with waste oil would benefit the entire community (for a government operated system)

A number of potential community applications for waste oil burning systems have been identified:

- o The Public Works Department of the City of Yellowknife has expressed interest as it has several major fuel oil consumers, and there are concerns about disposal of waste oil.
- o The Public Works Department at Inuvik uses over 70,000 litres of fuel oil per year to heat public buildings and there is some interest in replacing part of this by installing waste oil burners.
- o NCPC at Inuvik is prepared to consider burning more waste oil at its central heating plant and could accommodate up to 300,000 litres per year, provided it was pre-treated.

Individual users will continue to burn waste oil on a smaller scale, and economics will probably dictate the progression of the waste oil space heater.

5.3.4 Collection, Storage and Preprocessing

The type of collection and preprocessing systems required will depend to a large extent on the application and the quantities involved.

Individual burners of waste oil are usually also the producers of the oil and therefore take care of their own collection and their own pre-filtering requirements, if any.

For a larger system, such as the one at Hay River, a complete collection system would be required to guarantee a sufficient supply of waste oil. Oil collection could be run by the community, or contracted out to a private firm. Smaller producers of waste oil would be encouraged to drop off their oil at designated collection points, from where it would be picked up and taken to the storage and preprocessing area.

The size of the storage tanks will depend on whether the plant operates seasonally or continuously, and on whether the oil is obtained continuously or on an intermittent basis such as twice a year.

Preprocessing is desirable to ensure constant quality of fuel, to reduce water content, and to reduce particulates and contaminants.

5.3.5 Costs

(a) Value of Waste Oil to its Producer

As described in Section 5.1.4, it is assumed that waste oil, which is available for recycling, will have no monetary value before pick-up.

(b) Large Facility - Capital, Operation and Maintenance Costs

In order to obtain realistic cost figures on a "per litre" basis, the Hay River project is used as an example to illustrate economic factors considered in this type of plant. In a plant such as this the equivalent fuel costs are very dependent on capital costs and on the quantity of virgin oil displaced. It is noted that these figures are estimates and may change once the plant has been completed and is in operation.

Capital Cost: \$327,100	
Amorized Over 20 Years @ 10%	\$ 38,400/year
O & M Costs	<u>\$ 23,000/year</u>
Total	\$ 61,400/year

The plant is estimated to burn/replace 275,000 litres of oil per year.

The equivalent fuel costs when burning waste oils is given by:

$$\frac{\$ 61,400}{275,000 \text{ litres}} = \$0.22/\text{litre}$$

This compares favourably to a virgin oil price of \$0.30 - \$0.40/litre.

Cost Summary	Hay River Example Only (¢/Litre)
Cost of Fuel	0
Capital, O & M Costs	<u>22</u>
Total Costs	22
 Cost of Displaced Virgin Fuel	 30 - 40
Cost Savings	+ 8 to + 18

TABLE 5.1
ESTIMATE OF PERCENTAGE OF
WASTE OIL CONTAMINATED WITH LEAD

Assumptions:

- All waste oil is either crankcase oil or contaminated fuel
- 50% of all vehicles using gasoline require unleaded fuel

Total Waste Oil Generated = 1.8×10^6	1.8×10^6 L/a
Total Gasoline Sold in 1985	46.9×10^6 L/a
Total Diesel Fuel Sold in 1985	230.2×10^6 L/a
Total Fuel Sold	277.1×10^6 L/a
% Gasoline of Total Fuel	17.0%

It has been assumed that waste oils from vehicles will be accumulated at the same ratio as fuels sold. This means that 17% of waste oils from vehicles will be from gasoline powered vehicles.

Waste Oil From all Vehicles (Table 2.5) =	1.65×10^6 L/a
Waste Oil From Leaded Gasoline Powered Vehicles: $1.65 \times 10^6 \times 0.17 \times 0.5 =$	0.14×10^6 L/a

When this quantity is divided by the total waste oil generated, the resulting percentage of waste oil from leaded gasoline powered vehicles is 7.8%.

Note: Data for gasoline and diesel fuels sold are taken from the NWT Data Book 1986-87.

6.0 ECONOMICS

6.1 COST COMPARISON OF THREE POTENTIAL ALTERNATIVES

In the preceding section, costs were established for the three alternatives chosen. Although these costs are very approximate, they establish order of magnitude costs which are useful in comparisons and in providing an understanding of the relationships involved and the key parameters in the development of costs.

These relationships are shown in the following table.

TABLE 6.1
ECONOMIC COMPARISON OF ALTERNATIVES
(Profit(Loss) in ¢/Litre)

Alternative	Region			
	<u>South West</u>	<u>West Central</u>	<u>North West</u>	<u>North Central</u>
Re-Refine in Edmonton	- (14)	- (16)	- (21)	- (37)
Re-Refine in Vancouver	- (27)	- (29)	- (34)	- (50)
Build and Operate Re-Refinery in Hay River	- (65)	- (67)	- (71)	- (88)
Burn Waste Oil for Heating	+ 8	+ 8	+ 8	+ 8

The above table shows that that most economic way to dispose of waste oils is to burn them. It can be assumed that a waste oil fired heating plant should at least break even and, possibly provide some fuel cost savings.

Re-refining waste oils in Edmonton is not attractive at the present cost structure, and long and expensive transportation routes make re-refining in Vancouver even less attractive than in Edmonton.

Construction and operation of a re-refinery in the NWT is the least attractive option economically. This is due to the small size of the re-refinery, for which economies of scale cannot provide benefits in terms of unit capital and operations costs.

6.2 SENSITIVITIES

There are a number of parameters that might influence the economics of waste oil recycling:

1. Handling and Storage Charges

Agreements might be reached with the operators of tank farms and fuel distributors to regard waste oil as a special problem and charge only their cost for handling and storage.

2. Regional Transportation Charges

Negotiations with the barge companies could lead to special back-haul rates for waste oil to Hay River. This would have a considerable effect on the northern communities, since their shipping costs are highest.

3. Transportation From Hay River to Rerefinerries

The rates quoted by the trucking companies to Edmonton are already back-haul rates, and no reduction can be anticipated. The truck rate to Vancouver is a composite rate, reflecting back-haul rates for a portion of the route. No reduction in any of these rates may be anticipated.

It is understood that CN's rates are very high, to the extent that a negotiated 50% reduction would not make them competitive with alternative transportation rates.

4. Price Paid by the Re-Refineries for Feed Stock

The price paid by the re-refineries for feed stock depends on a number of factors:

- o the world price of crude oil
- o the demand for re-refined oil
- o the supply of waste oil feed stock

The world price of crude, currently at approximately U.S. \$18 per barrel is at about one-half of its peak value two years ago. The price of crude oil is not expected to reach such high levels in the near to mid term. The National Energy Board, in a recent (October, 1986) publication, "Canadian Energy, Supply and Demand 1985-2005" projects crude prices, in real terms, to remain between U.S. \$18 and U.S. \$27 per barrel for the next 20 years.

Re-refining industry experts have advised against plotting the price paid for feed stock against the world price for crude because supply and demand of re-refined oils and feed stock play an equally, if not more important role.

Demand for re-refined oil dropped sharply when virgin oil prices dropped. Compounding the matter, railroads, which traditionally used substantial amounts of re-refined oil, are installing lubrication systems based on grease and continue to purchase decreasing amounts of oil.

The waste oil supply market is in a surplus situation; legislation or proposed legislation in many areas is increasing the availability of waste oil amounts because road oiling and burning are being discouraged.

Thus it can be concluded that the value of waste oil as feed stock for re-refineries will not change substantially in the near future.

It will only be possible to re-refine oil from the N.W.T. in Southern Canada economically if several of the parameters above change simultaneously and substantially (higher prices paid for waste oil and lower costs of transporting it to the re-refinery).

7.0 SUMMARY AND RECOMMENDATIONS

7.1 SUMMARY

The Northwest Territories produce a substantial amount of waste liquid petroleum. In total, approximately 1.8 million litres are produced annually, of which over 800,000 litres/annum are currently not used for dust suppression, fire fighting exercises, or as fuel.

A variety of processes for re-refining waste oils exist and have been successfully applied. In Western Canada, the major facilities are the TURBO re-refinery in Edmonton utilizing the acid clay process and the MOHAWK re-refinery in Vancouver using the distillation hydrofinishing process. Currently, only MOHAWK is accepting waste oil provided it is of good quality and at little or no cost, while TURBO is not accepting additional waste oil deliveries because of difficulties selling the finished product.

The burning of waste oil for heat recovery is feasible. In the United States, over 50% of the waste oil produced is burned for heat. A concern may be the emission of lead pollutants into the atmosphere. Lead is found mainly in the crankcase oil of regular gasoline powered vehicles. However, lead is being phased out as an additive to gasoline and even now over 90% (by volume) of the waste oils in the NWT are reasonably free of lead contamination.

A waste-oil fired municipal water heating plant is being built in Hay River. It includes fuel pre-processing and a pollution monitoring program under the direction of Environment Canada.

Three potential alternatives for the disposal of waste oil were researched for the NWT, namely:

- 1) Re-refine the oil in Southern Canada
- 2) Build a re-refinery in the NWT
- 3) Burn the waste oil as a fuel for heating

Only the third alternative, to burn the waste oil, shows promise of being economically viable.

Re-refining the waste oil in Southern Canada may become economically feasible if the costs of getting the waste oil to the re-refinery are substantially reduced and the price paid for the waste oil raises considerably. This is not expected to happen in the next 20 years.

Building a re-refinery in the NWT is not economically viable at current waste oil quantities. A waste oil increase of at least one order of magnitude is required before a re-refinery could operate profitably in the Northwest Territories. This type of increase is not anticipated in the foreseeable future. The greatest potential for waste oil increases comes from oil exploration in the North, but no substantial activity is anticipated by the oil companies for at least 4 to 5 years.

7.2 RECOMMENDATIONS

It is recommended that the waste oil in the Northwest Territories be burned as fuel for heating. This solution would provide the following advantages:

- o Elimination of the waste oil disposal problem
- o Less danger of polluting community water supplies
- o Economic benefit from a waste product
- o A cleaner environment
- o No financial burden on the government for the disposal of waste oil

Emissions from the burning operations can be controlled and avoided through waste oil preprocessing and pollution monitoring.

Initially, the large users of fuel oil for heat in Yellowknife and Inuvik should be verified and quantities of heat/oil per plant established. Potential large users of heat in other communities should also be researched. All projects identified

should be checked for economic and technical feasibility. The required waste oil stream must be verified and secured and collection systems must be established.

Given the decentralized nature of the smaller communities in the NWT, and the long transportation distances between them, it is preferable if wastes can be eliminated/utilized locally and in smaller communities, where large central heating units are not feasible, the possibility of utilizing smaller space heaters could be researched.

Present use of waste oil fired space heaters should not be discouraged, unless it is found that these heaters are hazardous to the environment.

The development of the Hay River waste oil fired heating facility should be closely monitored. This is a type of test case that should indicate the economics of waste oil burning.

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Canadian Energy, Supply and Demand 1985-2005, National Energy Board,
October, 1986.

Personal Visits

Turbo Refinery, Edmonton, Alberta

Northern Canada Power Commission, Edmonton, Alberta.

PERSONAL COMMUNICATIONS

- ATL, Calgary, Alberta
- B.C. Ministry of Environment, Victoria, B.C.
- Buffalo Airways, Hay River
- Byers Transport, Edmonton, Alberta; Yellowknife
- Canadian Coast Guard, Vancouver, B.C.; Hay River
- Canadian National Railways, Edmonton, Alberta
- City of Yellowknife, Public Works Department
- Con Mine, Yellowknife
- Department of Environment, Government of New Brunswick
- Dome Petroleum, Calgary, Alberta
- Environment Canada, Ontario Region - Toronto
- Esso Resources, Calgary, Alberta
- Frame and Perkins Ltd., Yellowknife
- Giant Yellowknife Mine
- Government of the Northwest Territories, Department of Public Works and Highways
- Gulf Oil/Beaudril, Calgary, Alberta
- Kenn Borek Air Ltd., Inuvik
- Manitoba Environment & Work Place Safety & Health, Winnipeg, Manitoba
- Ministry of Environment, Ontario
- Mohawk Lubricants, Vancouver, B.C.
- Mondry, Del Zotto, Montreal, Quebec
- Nahanni Air Services, Norman Wells
- Norman Wells Transport Company
- North Star Services and Construction, Inuvik
- Northwestern Air Lease, Fort Smith
- NTCL, Edmonton, Alberta
- Pacific Western Airlines, Edmonton, Alberta
- Points North Transportation, Inuvik
- Pollution Probe, Toronto
- Remple Trucking, Edmonton, Alberta
- Robinson's Trucking, Yellowknife
- Saskatchewan Environment, Regina, Saskatchewan
- Town of Inuvik, Public Works Department
- TRIMAC, Edmonton, Alberta
- Yellowknife Motors

APPENDIX I

**TELEPHONE QUESTIONNAIRE
WASTE OIL GENERATED**

APPENDIX I

TELEPHONE QUESTIONNAIRE WASTE OIL GENERATED

Contact: _____ Date: _____
Location: _____
Telephone No. _____

Type of Waste Oil:	Quantity
☐ Lube Oil	_____
☐ Solvents	_____
☐ Contaminated Fuels	_____

Is this waste oil available for recycling? _____
What is it used for now? _____
How much of it could be made available? _____
Any problems with present disposal methods? _____

Comments/Suggestions?

APPENDIX 2

**WASTE LIQUID PETROLEUM IN A
SELECTION OF MAJOR COMMUNITIES**

APPENDIX 2

WASTE LIQUID PETROLEUM AT YELLOWKNIFE

Source Cat. ¹	Company	Waste Oils & Solvents (L/a)	Contaminated Fuels (L/a)	Comments
A.	(All maintenance at Ray River.)	Nil	Nil	
B.	PWA - all maintenance in Edmonton	-	-	
	Northwest Territorial Airways	10,600 - 14,000 (12,300 average)	-	
	Other	3,000	-	Estimate
C.	Cominco - Con Mine	50,000	-	
	Giant Yellowknife Mine	82,600	-	
D.	NCPC	12,500	-	
	NWT - Dept. of Highways	9,000	-	
	City Public Works	3,700	-	
E.	Esso Petroleum Canada	-	2,000	
	Mantonabee Holdings Ltd.	-	1,000	Estimate
F.	Robinson's Trucking (Construction)	6,400	3,600	
	Fred H. Ross & Assoc. Ltd.	2,000	-	Estimate
	Other	<u>500</u>	<u>-</u>	
	TOTAL	182,000	6,600	

¹ Categories are described on a separate sheet "Major Waste Oil Producing Categories," in this appendix.

² All totals represent average values.

³ "-" indicates no quantities available or zero quantity is assumed.

WASTE LIQUID PETROLEUM AT INUVIK

Source Cat. ¹	Company	Waste Oils & Solvents (L/a)	Contaminated Fuels (L/a)	Comments
A.	Maintenance at Hay River or Tuk.	Nil	Nil	
B.	Aklak Air Ltd.	2,500	1,000	Estimate
	Ken Bovek Air Ltd.	2,500	1,800	
	Others	2,500	1,000	Estimate
C.	--	-	-	
D.	NCPC	57,100	-	
	Town Public Works	500	-	Estimate
E.	Hansen Petroleum Products Ltd.		2,000	Estimate
F.	North Star Serv. & Const.	3,100	-	
	Points North Transportation Inc.	22,750	-	
	Others	<u>2,000</u>	<u> </u>	Estimate
	TOTAL	92,950	5,800	

¹ Categories are described on a separate sheet "Major Waste Oil Producing Categories," in this appendix.

² All totals represent average values.

³ "-" indicates no quantities available or zero quantity is assumed.

WASTE LIQUID PETROLEUM AT TUKTOYAKTUK

Source Cat.1	Company	Waste Oils & Solvents (L/a)	Contaminated Fuels (L/a)	Comments
A.	ATL	135-160,000 (av. - 147,500)	To Hay River	
B.	--	-	-	
C.	Gulf/Beaudril	688,000	Incl.	*
	Dome Petroleum	200,000	500,000	*
	Esso Resources	100,000	200,000	* Estimate
D.	NCPC	500	-	
E.	--			
F.	2 smaller companies	<u>1,000</u>	<u>-</u>	
	TOTAL	149,000	-	

*Only during drilling activities.

1 Categories are described on a separate sheet "Major Waste Oil Producing Categories," in this appendix.

2 All totals represent average values.

3 "-" indicates no quantities available or zero quantity is assumed.

* Waste oil and contaminated fuels from oil exploration activities are not included in the total.

WASTE LIQUID PETROLEUM AT NORMAN WELLS

Source Cat.1	Company	Waste Oils & Solvents (L/a)	Contaminated Fuels (L/a)	Comments
A.	--	-	-	
B.	Nahanni Air Services	100	-	
	Others	100	-	
C.	Esso - Imperial Oil	57,240	-	
D.	NCPC	6,600	-	
E.	Norman Wells Transport Co. (Rentals, Heavy Equip., Contract, Esso Serv.)	600	-	
F.	(see E above)			
	Carn Construction	600	-	Estimate
	Others	<u>400</u>	<u>-</u>	Estimate
	TOTAL	65,640	-	

1 Categories are described on a separate sheet "Major Waste Oil Producing Categories," in this appendix.

2 All totals represent average values.

3 "-" indicates no quantities available or zero quantity is assumed.

WASTE LIQUID PETROLEUM AT FORT SMITH

Source Cat.1	Company	Waste Oils & Solvents (L/a)	Contaminated Fuels (L/a)	Comments
A.	--	-	-	
B.	Northwestern Air Lease	3,640	680	Estimate
	Fort Smith Air Service	1,800	400	
	Others	2,000	500	
C.	--	-	-	
D.	NCPC	2,700	-	
	Town Public Works	250	-	
E.	K&M Enterprises Ltd.	-	2,000	Estimate
	Peterson Oil Sales Ltd.	-	2,000	Estimate
F.	Brown's Transport Ltd.	3,000	-	
	Herons Trucking			
	Others			
TOTAL		13,390	5,580	

1 Categories are described on a separate sheet "Major Waste Oil Producing Categories," in this appendix.

2 All totals represent average values.

3 "-" indicates no quantities available or zero quantity is assumed.

WASTE LIQUID PETROLEUM AT FORT SIMPSON

Source Cat.1	Company	Waste Oils & Solvents (L/a)	Contaminated Fuels (L/a)	Comments
A. --		-	-	
B. 3 smaller companies		1,000	200	Estimate
C. --		-	-	
D. NCPC		24,000	-	
E. Pat's Aviation Refueling Serv. A&A Service & Equipment		- -	1,500 1,000	Estimate Estimate
F. 2 Smaller Companies		<u>300</u>	<u>-</u>	
TOTAL		25,300	2,700	

- 1 Categories are described on a separate sheet "Major Waste Oil Producing Categories," in this appendix.
- 2 All totals represent average values.
- 3 "-" indicates no quantities available or zero quantity is assumed.

WASTE LIQUID PETROLEUM AT PINE POINT

Source Cat. ¹	Company	Waste Oils & Solvents (L/a)	Contaminated Fuels (L/a)	Comments
A. --		-	-	
B. --		-	-	
C. Cominco Mines, Closing 1987		-	-	
D. NCPC		5,100	-	
E. --		-	-	
F. Tundra Drilling Corp.		500	-	Estimate
Others		<u>200</u>	<u> </u>	Estimate
TOTAL		5,800		

¹ Categories are described on a separate sheet "Major Waste Oil Producing Categories," in this appendix.

² All totals represent average values.

³ "-" indicates no quantities available or zero quantity is assumed.

MAJOR WASTE OIL PRODUCING CATEGORIES

- A. Marine
 - Transport
 - NTCL
 - ATL
- B. Air Transport
- C. Major Industries
 - Oil - producing or exploration
 - Mines
 - Other
- D. Services
 - Electrical Generation (NCPC, Northlands Utilities Ltd.)
 - Dept. of Highways - NWT
 - Municipal - Public Works
 - Canadian Coast Guard
- E. Bulk Fuel Plants
- F. Highway and Heavy Construction
- G. Trucking
- H. Automobiles